dividing the collected radiation into two collected rays having different polarization states;

detecting the two rays to provide two outputs; and

deriving the one or more parameters from the two outputs.

B1 Cont'd

2. The method of claim 1, wherein the dividing divides the collected radiation into an ordinary ray and an extraordinary ray, said two rays having substantially orthogonal polarizations.

3. The method of claim 1, wherein the directing includes passing the collected radiation through an optical element having a plane of polarization at an angle different from 0, 90, 180 and 270 degrees to the plane of incidence.

4. The method of claim 1, wherein the dividing includes passing the collected radiation through an optical element having a plane of polarization at an angle of about 0, 45, 90, 135, 180, 225, 270 or 315 degree to the plane of incidence.

5. The method of claim 1, wherein the directing directs an unpolarized beam to the structure, and wherein the dividing includes passing the collected radiation through an optical element having a plane of polarization at an angle of about 0, 90, 180 or 270 degree to the plane of incidence.

6. An apparatus for measuring one or more parameters of a periodic structure, comprising:

an instrument directing a polychromatic beam of electromagnetic radiation to the structure;

optics collecting radiation from the beam after it has been modified by the structure;

a device dividing the collected radiation into two collected rays having different polarization states;

detectors detecting the two rays to provide two outputs; and

a processor deriving the one or more parameters from the two outputs.

7. The apparatus of claim 6, wherein the device divides the collected radiation into an ordinary ray and an extraordinary ray, said two rays having substantially orthogonal polarizations.

B1 Cont'd

8. The apparatus of claim 6, wherein the instrument includes an optical element having a plane of polarization at a non-zero angle to the plane of incidence, wherein said plane of polarization is not perpendicular to the plane of incidence.

9. The apparatus of claim 6, wherein the device includes an optical element having a plane of polarization at an angle to the plane of incidence, where the angle is about 0, 45, 90, 135, 180, 225, 270 or 315 degree.

10. The apparatus of claim 6, wherein the instrument directs an unpolarized beam to the structure, and wherein the device includes an optical element passing the collected radiation, said optical element having a plane of polarization at an angle of about 0, 90, 180 or 270 degree to the plane of incidence.

11. The apparatus of claim 6, wherein the instrument focuses the beam to the structure and each of said instrument and said optics has a numerical aperture, and wherein the numerical aperture of the optics is smaller than that of the instrument.

12. A method for measuring one or more parameters of a periodic structure, comprising:

(a) directing a polychromatic beam of electromagnetic radiation to the structure in a plane of incidence;

(b) collecting radiation from the beam after it has been modified by the structure;

(c) passing the collected radiation through a first polarizing element having a polarization plane at a first angle to the plane of incidence;

(d) detecting the collected radiation passing through the element to provide an output;

NK (e) altering the first angle between the two planes to a different value and repeating (a), (b), (c) and (d), wherein said different value remains ~~substantially~~ stationary when (a), (b), (c) and (d) are repeated to provide at least an additional output; and

(f) deriving the one or more parameters from the outputs.

13. The method of claim 12, wherein said different stationary value of the angle is one of 0, 45, 90, 135, 180, 225, 270 and 315 degrees.

B1 Cont'd

14. The method of claim 12, wherein said directing includes passing radiation through a second polarizing element having a polarization plane at a second angle to the plane of incidence, said second angle having a value different from 0, 90, 180 and 270 degrees.

15. The method of claim 14, wherein said polarization planes of the two elements are substantially parallel or perpendicular to each other.

16. An apparatus for measuring one or more parameters of a periodic structure, comprising:

a source directing a polychromatic beam of electromagnetic radiation to the structure in a plane of incidence;

optics collecting radiation from the beam after it has been modified by the structure;

a first polarizing element having a polarization plane at a first angle to the plane of incidence passing the collected radiation;

a detector detecting the collected radiation that has passed through the element to provide an output;

an instrument rotating the first element relative to the plane of incidence to alter the value(s) of the first angle to one or more different value(s) that remain substantially stationary when said detector is detecting the collected radiation, so that the detector provides at least one output before and after the first angle is altered; and

a processor deriving the one or more parameters from the outputs.

17. The apparatus of claim 16, wherein said different value of the first angle is one of 0, 45, 90, 135, 180, 225, 270 and 315 degrees.

18. The apparatus of claim 16, said source including a second polarizing element passing radiation to provide said beam, said second element having a polarization plane at a second angle to the plane of incidence, said instrument rotating one or more of the two elements relative to the plane of incidence to alter the value(s) of the first and/or the second

angle to one or more different value(s) that remain substantially stationary when said detector is detecting the collected radiation.

B1 Cnt'd

19. The apparatus of claim 18, wherein said different value(s) of the first and/or second angle are one of 0, 45, 90, 135, 180, 225, 270 and 315 degrees.

20. The apparatus of claim 16, wherein the source focuses the beam to the structure and each of said source and said optics has a numerical aperture, and wherein the numerical aperture of the optics is smaller than that of the source.

21. The apparatus of claim 16, wherein said source includes a second polarizing element having a polarization plane at an angle to the plane of incidence, said second element passing radiation to provide said beam, said angle having a value different from 0, 90, 180 and 270 degrees.

22. The apparatus of claim 21, wherein said polarization planes of the two elements are substantially parallel or perpendicular to each other.

23. An apparatus for measuring one or more parameters of a periodic structure, comprising:

an optical device including a first element directing a polychromatic beam of electromagnetic radiation to the structure in a plane of incidence and a second optical element passing radiation from the beam after it has been modified by the structure, said two elements attached together to form an integrated unit or being an integral unit;

said second element having a plane of polarization; and

at least one detector detecting the collected radiation that has passed through the second element to provide at least one output.

24. The apparatus of claim 23, said plane of polarization is at an angle to the plane of incidence, said angle having a value different from 0, 90, 180, 270 degrees.

25. The apparatus of claim 24, wherein said plane of polarization is at an angle of about 0, 45, 90, 135, 180, 225, 270 or 315 degree to the plane of incidence.

B1 Cont'd

26. The apparatus of claim 23, wherein the second element divides the radiation from the beam after it has been modified by the structure into an ordinary ray and an extraordinary ray, said two rays having substantially orthogonal polarizations, said apparatus further comprising two detectors, each of the two detectors detecting a corresponding one of the two rays.

27. The apparatus of claim 23, wherein each of said two elements has a numerical aperture, and wherein the numerical aperture of the second element is smaller than that of the first.

28. The apparatus of claim 23, further comprising a processor deriving the one or more parameters from the output.

29. An apparatus for inspecting a sample having a periodic structure thereon, comprising:

(a) a detection system including:

a device directing a polychromatic beam of electromagnetic radiation to the structure;

optics collecting radiation from the beam after it has been modified by the structure; and

at least one detector detecting the collected radiation to provide at least one output;

(b) a first instrument causing translational motion of the sample in a first direction; [and]

(c) a second instrument causing translational motion between the first instrument and the system in a second direction transverse to the first direction; and

(d) a processor deriving one or more parameters of the periodic structure from the at least one output.

30. The apparatus of claim 29, said system further including a polychromatic radiation source, and the second instrument causes translational motion of the source.

31. The apparatus of claim 29, said system further including a conduit carrying a collimated beam of radiation.

B1 Cont'd

32. The apparatus of claim 29, further including an optical arrangement directing an incoming radiation beam to the detection system along different optical paths when relative motion is caused between the system and the sample, so that the different optical paths have substantially the same optical path length.

33. The apparatus of claim 29, said arrangement including a radiation reflective element that moves together with the second instrument reflecting radiation towards the device along optical paths that are substantially at 45 degrees to a trajectory of the device when moved by the two instruments.

34. An apparatus for inspecting a sample having a structure thereon, comprising:

(a) a detection system including:

a device directing a polychromatic beam of electromagnetic radiation to the structure;

optics collecting radiation from the beam after it has been modified by the structure; and

at least one detector detecting the collected radiation to provide at least one output, said detector comprising a spectrometer detecting the collected radiation at a plurality of distinct wavelengths simultaneously;

NA

(b) an instrument causing first motion of the sample, and second motion between the first instrument and the system, wherein one of the two motions is translational and the remaining motion is translational or rotational.

35. The apparatus of claim 34, said system further including a polychromatic radiation source.

36. The apparatus of claim 34, said system further including a conduit carrying a collimated beam of radiation.

B1 Cont'd

37. The apparatus of claim 34, further including an optical arrangement directing an incoming radiation beam to the detection system along different optical paths when relative motion is caused between the system and the sample, so that the different optical paths have substantially the same optical path length.

38. The apparatus of claim 34, said arrangement including a radiation reflective element that moves together with the second instrument reflecting radiation towards the device along optical paths that are substantially at 45 degrees to a trajectory of the device when moved by the two instruments.

39. An integrated processing and detection apparatus for processing a sample having structures thereon, comprising:

(a) a detection system for finding one or more parameters of a structure, wherein the system detects the structure by directing a polychromatic beam of electromagnetic radiation to the structure, collecting radiation from the beam after it has been modified by the structure; said system including:

a device dividing the collected radiation into two collected rays having different polarization states;

detectors detecting the two rays to provide two outputs; and

a processor deriving the one or more parameters from the two outputs; and

(b) a processing system processing the sample, said processing system responsive to said one or more parameters for adjusting a processing parameter.

40. The apparatus of claim 39, said detection system further including a radiation source that provides the polychromatic beam.

41. The apparatus of claim 39, further including a conduit for transmitting radiation to said detection system.

42. The apparatus of claim 41, said conduit including an optical fiber.

43. The apparatus of claim 39, further including an instrument causing relative motion between the detection system and the sample in order to detect an area of the sample,

an optical arrangement directing an incoming radiation beam to the detection system along different optical paths when relative motion is caused between the system and the sample, so that the different optical paths have substantially the same optical path length.

B1 Cont'd

44. The apparatus of claim 39, said detection system including one or more reflective optical elements that focus(es) radiation to the structure or collect(s) radiation from the structure.

45. An integrated processing and detection apparatus for processing a sample having structures thereon, comprising:

(a) a detection system for finding one or more parameters of a structure, wherein the system detects the structure by directing a polychromatic beam of electromagnetic radiation to the structure in a plane of incidence, collecting radiation from the beam after it has been modified by the structure; said detection system including:

a first polarizing element having a polarization plane at a first angle to the plane of incidence passing the collected radiation;

a detector detecting the collected radiation that has passed through the element to provide an output;

an instrument rotating the first element relative to the plane of incidence to alter the value(s) of the first angle to one or more different value(s) that remain substantially stationary when said detector is detecting the collected radiation, so that the detector provides at least one output before and after the first angle is altered; and

a processor deriving the one or more parameters from the outputs;

(b) a processing system processing the sample, said processing system responsive to said one or more parameters for adjusting a processing parameter.

46. The apparatus of claim 45, said detection system further including a radiation source that provides the polychromatic beam.

47. The apparatus of claim 45, further including a conduit for transmitting radiation to said detection system.

48. The apparatus of claim 47, said conduit including an optical fiber.

B1 Cont'd

49. The apparatus of claim 45, said system further including a second instrument causing relative motion between the detection system and the sample in order to detect an area of the sample, said system further including an optical arrangement directing an incoming radiation beam to the detection system along different optical paths when relative motion is caused between the system and the sample, so that the different optical paths have substantially the same optical path length.

50. The apparatus of claim 45, said detection system including one or more reflective optical elements that focus(es) radiation to the structure or collect(s) radiation from the structur.

51. An integrated processing and detection apparatus for processing a sample having a structure thereon, comprising:

(a) a detection system including:

a device directing a polychromatic beam of electromagnetic radiation to the structure;

optics collecting radiation from the beam after it has been modified by the structure; and

at least one detector detecting the collected radiation to provide at least one output;

(b) a first instrument causing motion of the sample;

(c) a second instrument causing relative motion between the first instrument and the system so that the beam has access to any location of the sample; and

(d) a processing system processing the sample, said processing system responsive to said at least one output for adjusting a processing parameter.

52. The apparatus of claim 51, said detection system further including a radiation source that provides the polychromatic beam.

53. The apparatus of claim 51, further including a conduit carrying a collimated beam of radiation to the detection system.

B1 Cont'd

54. The apparatus of claim 51, further including an optical arrangement directing an incoming radiation beam to the detection system along different optical paths when relative motion is caused between the system and the sample, so that the different optical paths have substantially the same optical path length.

55. The apparatus of claim 51, said two instruments causing translational motion that are substantially perpendicular to each other, said arrangement including a radiation reflective element that moves together with the second instrument reflecting radiation towards the device along optical paths that are substantially at 45 degrees to a trajectory of the device when moved by the two instruments.

56. The method of claim 1, wherein the detecting detects at least one of the two rays by means of a spectrometer to provide outputs at a plurality of wavelengths.

57. The method of claim 1, wherein the directing comprises focusing radiation to the structure.

58. The method of claim 1, wherein the detecting detects reflectance of the structure at a plurality of wavelengths.

59. The method of claim 1, wherein the deriving derives a critical dimension, height or sidewall angle of the structure.

60. The apparatus of claim 6, wherein at least one of the detectors comprises a spectrometer to provide outputs at a plurality of wavelengths.

61. The apparatus of claim 6, wherein the instrument comprises an objective focusing radiation to the structure.

62. The apparatus of claim 6, wherein at least one of the detectors detects reflectance of the structure at a plurality of wavelengths.

B1 Cont'd

63. The apparatus of claim 6, wherein the processor derives a critical dimension, height or sidewall angle of the structure.

64. The apparatus of claim 29, wherein the processor derives a critical dimension, height or sidewall angle of the structure.

65. The apparatus of claim 34, wherein the processor derives a critical dimension, height or sidewall angle of the structure.

66. The apparatus of claim 39, wherein the processor derives a critical dimension, height or sidewall angle of the structure.

67. The apparatus of claim 45, wherein the processor derives a critical dimension, height or sidewall angle of the structure.

68. The apparatus of claim 51, wherein the processor derives a critical dimension, height or sidewall angle of a periodic structure of the sample.

69. The method of claim 12, wherein the detecting detects at least one of the two rays by means of a spectrometer to provide outputs at a plurality of wavelengths.

70. The method of claim 12, wherein the directing comprises focusing radiation to the structure.

71. The method of claim 12, wherein the detecting detects reflectance of the structure at a plurality of wavelengths.

72. The method of claim 12, wherein the deriving derives a critical dimension, height or sidewall angle of the structure.

73. The apparatus of claim 16, wherein the detector comprises a spectrometer to provide outputs at a plurality of wavelengths.

74. The apparatus of claim 16, wherein the source comprises an objective focusing radiation to the structure.

B1 Cont'd

75. The apparatus of claim 16, wherein the detector detects reflectance of the structure at a plurality of wavelengths.

76. The apparatus of claim 16, wherein the processor derives a critical dimension, height or sidewall angle of the structure.

77. The apparatus of claim 23, wherein the at least one detector comprises a spectrometer to provide outputs at a plurality of wavelengths.

78. The apparatus of claim 23, wherein the first element comprises an objective focusing radiation to the structure.

79. The apparatus of claim 23, wherein the at least one detector detects reflectance of the structure at a plurality of wavelengths.

80. The apparatus of claim 23, further comprising a processor deriving a critical dimension, height or sidewall angle of the structure.

81. (New) A wafer measurement system for use within a wafer process tool, comprising:

6084047

a wafer measurement station forming one of the stations of the wafer process tool, the measurement station having a wafer support, the measurement station also having therein an optical measurement system forming a scatterometry instrument that is moveable by a stage to specified locations over the wafer support, the optical measurement system optically coupled to a light source to direct a light beam as a spot onto patterned features on a wafer surface on the wafer support, the head also having a light collector associated with a detector whereby illuminated features on the wafer yield characteristic optical signatures with independent optical parameters in the signatures; and

a data processor analyzing the characteristic signatures of a wafer using a scattering model for possible periodic structures on a wafer to obtain a measure of the patterned features on the wafer so that a process carried out by the wafer process tool can be analyzed.

B1 cont'd

82. (New) The apparatus of claim 81 wherein the optical measurement system includes an objective lens imaging light from a spot on the wafer.

83. (New) The apparatus of claim 81 wherein the light beam incident on the wafer is substantially unpolarized.

84. (New) The apparatus of claim 81 wherein the optical measurement head directs the light beam at normal incidence onto the wafer surface.

85. (New) The apparatus of claim 81 wherein the measure of patterned features obtained by the data processor includes at least one dimension of lateral or vertical geometric structure of features on the wafer.

86. (New) The apparatus of claim 85 wherein the measure of patterned features include line width and profile of features on the wafer.

87. (New) The apparatus of claim 86 wherein the profile of pattern features is characterized by a feature height or depth that may be variable with lateral position across the features, the scattering model used by the data processor taking such variable feature height or depth dependence on lateral position into account.

88. (New) The apparatus of claim 81 wherein the measure of patterned features obtained by the data processor includes film thickness.

89. (New) The apparatus of claim 81 further comprising a stage driving the optical measurement system.

90. (New) The apparatus of claim 81 wherein the wafer support is capable of moving a wafer in at least one dimension.

B1 Cont'd

91. (New) The apparatus of claim 90 wherein the wafer support provides (x,y) translation of a wafer.

92. (New) A scatterometry instrument integrated within a wafer measurement station that forms one station of wafer process tool, the wafer measurement station having a spectrometry instrument and a wafer support with a capacity for locating a wafer at a measurement position, wherein the scatterometry instrument comprises:

a movable stage;

an optical measurement system mounted on said stage for movement by said stage to one or more specified locations over a wafer held by a wafer support in the measurement position, the measurement system being in optical communication with a light source for directing a light beam as a spot onto patterned features on a wafer on the wafer support, the measurement system having collection optics associated with a detector for collecting and detecting light scattered from the portion of the wafer illuminated by the light beam, whereby features on the wafer yield characteristic optical signatures with independent optical parameters of the signatures; and

a data processor in communication with the detector, the data processor analyzing the characteristic optical signatures using a scattering model for possible periodic structures on a wafer to obtain a measure of the patterned features on the wafer such that a process carried out by the wafer process tool can be analyzed.

93. (New) The instrument of claim 92 wherein the optical measurement system directs the light beam at normal incidence onto the wafer.

94. (New) The instrument of claim 92 wherein the collection optics of the measurement system includes an objective lens positioned to image light scattered from a spot on the wafer.

95. (New) The instrument of claim 92 wherein the light source is optically coupled to the optical measurement system via an optical fiber.

B1 Cont'd

96. (New) The instrument of claim 92 wherein the light beam incident on the wafer is substantially unpolarized.

97. (New) The instrument of claim 92 wherein a measure of patterned features obtained by the data processor includes at least one dimension of lateral or vertical geometric structure of features on the wafer.

98. (New) The instrument of claim 97 wherein the measure of patterned features include line width and profile of features on the wafer.

99. (New) A wafer measurement method for cooperative use with a wafer process tool, comprising:

within the wafer process tool after completion of a process step carried out in processing stations of the process tool, receiving in an integrated measuring station of the process tool a waferin the measurement station relative to a moveable optical measurement system;

moving an optical measurement system to a plurality of locations over the wafer;

directing a beam of light normally onto the wafer surface as a light spot at each of said plurality of locations;

detecting light reflected from the wafer surface to obtain data for an optical characteristic of surface pattern features on the wafer at said plurality of locations; and

analyzing the optical characteristic data using a scattering model of possible periodic structures on a wafer to obtain a measure of critical dimensions of the surface pattern features on the wafer.

100. (New) The method of claim 99 further defined by sequentially measuring reflectance data for a plurality wafers received from the wafer process tool.

101. (New) A method of measuring a wafer within a wafer process tool, comprising:

transferring a wafer from a process station of the process tool to a measurement station of the process tool;

positioning a measurement spot of an optical head of a measurement instrument within the measurement station over a first location of the wafer;

rotating the wafer and translating the optical head to position the measurement spot over a second location of the wafer;

repeating the wafer rotation and optical head translation to successively position the measurement spot over different locations of the wafer; and

measuring an optical characteristic of the wafer at each of the successive measurement locations.

B1 End